

Lubricants for Wire Ropes – New Product Trends

by:

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Introduction:

Wire ropes are employed in industrial fields including mining, forestry, and shipping; and on applications such as building elevators (lifts), construction cranes, and suspension bridges. They offer flexible energy transmission with surprisingly high weight to power ratio. They also handle a wide array of load types including high stress loads, high speed loads, shock, jerky, and rapid accelerating or decelerating loads. They are used in hot, cold, dry, humid or submerged in water. Yet, many users choose to ignore them. The lifespan of a wire rope can be dramatically increased when it is coated with a lubricant. The variability in their use dictates the desired lubricant properties. Today, new legislative environmental guidelines are driving users to give consideration not only the wire rope typical lubricants that lubricate and protect, but that are also considerate to the environment.



Wire Ropes:

A rope is a series of braided or twisted strands combined to provide extra strength. A rope made mostly of steel strands is often called a cable or wire rope. Typically, the name wire rope is used when it is greater than 9.5 mm (3/8 inch) in diameter.

Wire ropes are graded based on their tensile strength ranging from 1570 N/mm² to as high as 1770 N/mm². Wire ropes are classified by size and length, grade of steel, lay, number of strands, and the number of wires in each strand. As depicted in Figure 1, the rope consists of several wire strands wrapped around a core in a spiral patch. The core could be metal or fiber in a way that would allow flexibility and freedom of movement for the entire rope while providing the support for the rope structure. Each of the strands are similarly formed of individual wire rods braided around a center wire rod.

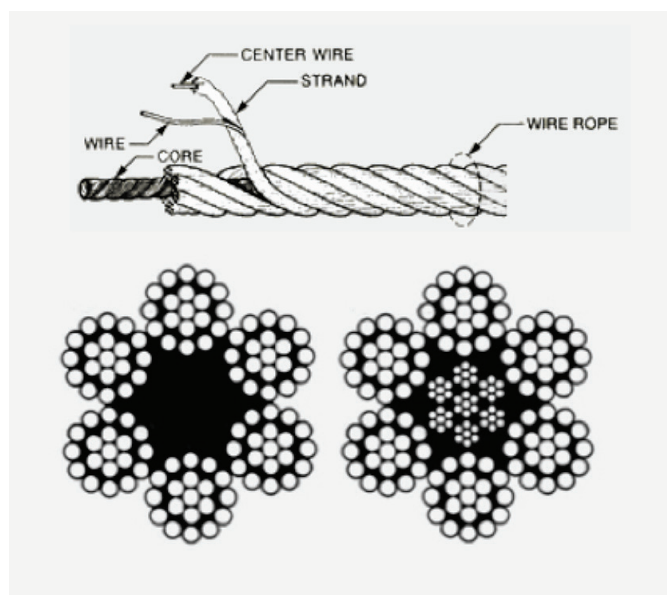


Figure 1. Structure of a typical wire rope; Bottom: Cutaway sections of wire ropes with fiber and metal cores¹

Wire Rope Lubricants:

At a high level there are two general categories of wire rope lubricants. The first category of lubricants is used during the manufacturing of wire ropes. Those are typically high viscosity lubricants that are embedded into the wire rope strands and

are expected to last for an extended period of time. The other category is the lubricants that are applied to wire ropes during service. There are two types of this second category, penetrating lubricants and coating lubricant. Those could be low viscosity lubricating penetrants or high viscosity oils or low consistency grade greases. As with most lubricants, wire rope lubricants can serve several purposes. As the name would suggest, they are first lubricants. Frequently, they are secondarily designed to coat and protect the rope from corrosion. Lack of lubrication would result in reduced longevity for wire ropes (Figure 2).



Figure 2. Without proper lubrication wire ropes degrade and lose longevity

Category 1 – Rope Manufacturing Lubricants: Wire rods are made from hot rolled, high carbon steel billets that are drawn to the desired diameter ranging from 5.5 mm to 8 mm. The rods are then heat treated (patented) to a specified micro structure. A second drawing may reduce this to smaller diameters adding mechanical stability and obtaining the desired diameter. During each of these processes suitable lubricants may be used because of the amount of force applied to the wires. In the process of “stranding” the wire strands are made by combining a number of

wires to be used on the core. Finally, in the process of “closing,” the sets of strands are laid in layers over the core completing the wire rope. The lubricant used at this stage is especially important in the longevity of the wire rope. Figure 3 illustrates the process starting from the wire rods and ending with wire ropes. The chemistry of the steel and its carbon content along with the heat treating process used in drawing the wire make for a variety of tensile strength, fatigue and wear resistance in the final product².

Category 2 – In-Service Wire Rope Lubricants: It was previously explained that there are two types of in-service wire rope lubricants that are commonly used, coating lubricants and penetrating lubricants. Formulation techniques used in an attempt to prepare hybrid products that provide some level of penetration while at the same time leave a coating.

Penetrating wire rope lubricants are typically low viscosity, fluid like products. These products range in consistency from low viscosity and solvent-like up to very sticky and viscous like corn syrup. Obviously, the level of penetration will be deeper and more rapid the lower the viscosity of the product.

Coating wire rope lubricants often contain thickeners, such as resins, asphaltic hydrocarbons, clay, grease soap, and waxes that once applied do not easily penetrate the rope, but instead leave a gel-to-almost-solid coating on the exterior of the rope. While this type lubricant may not as easily penetrate into the rope, it provides stronger protection against ingress of abrasive contamination and rusting of the rope by providing a stronger external barrier between the rope and the service environment.

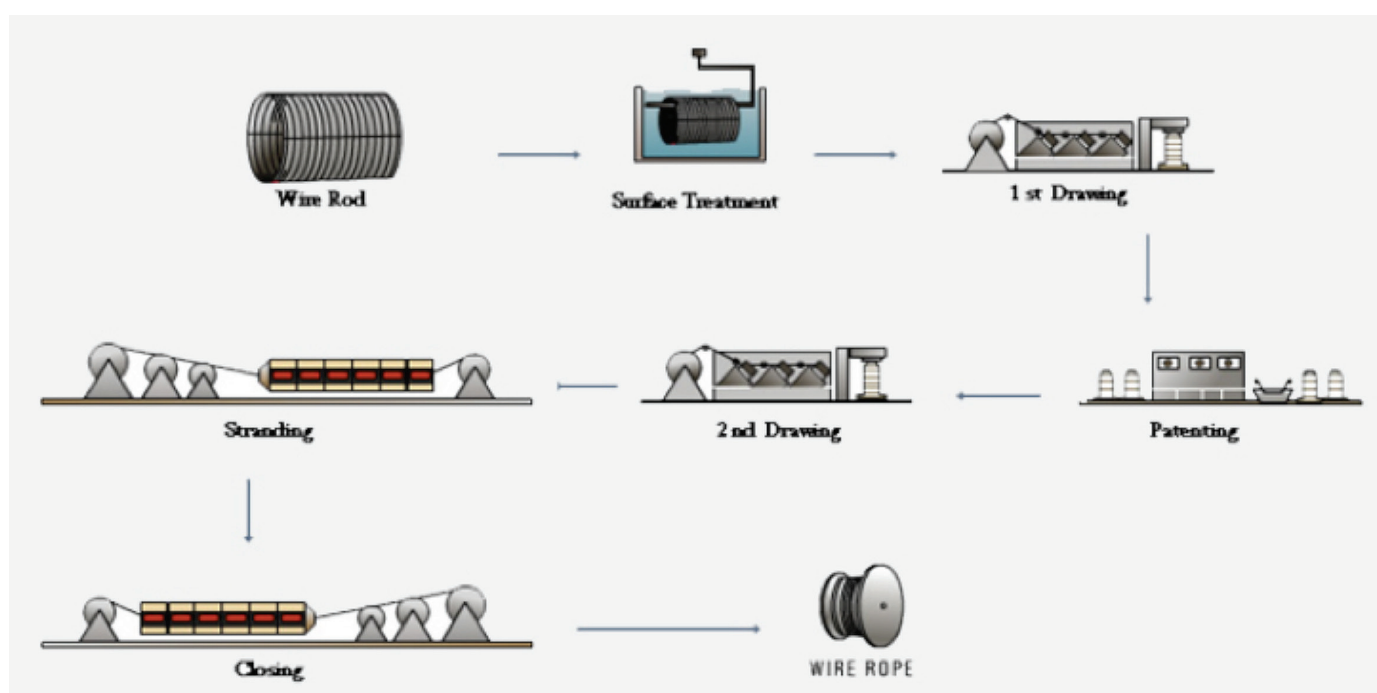


Figure 3. Wire rope manufacturing process²

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Hybrid wire rope lubricants are typically versions of coating lubricants that are diluted with volatile solvents to dramatically reduce the viscosity. The reduced viscosity allows for better rope penetration. Once applied the volatile solvent evaporates out and leaves behind either a high viscosity or hard coating on the rope from the inside out. Volatile compounds are losing favor in today's more environmentally conscience users, making it much more difficult to formulate these hybrids.

Wire Rope Lubricant Formulations

Wire Rope lubricants are often formulated from typical components. The components can be divided into three main types: base fluids, thickener, and performance enhancing additives.

Base Fluids: This is a description for a very wide variety of substances. Traditionally, many have been come from petroleum sources, such as oil or solvents. The base fluid is often the highest concentration ingredient in the product formula. Today, environmental rules, such as the EPA's Vessel General Permitting regulations, described in more detail later, can deter a user from being able to use a petroleum based product, therefore today biodegradable vegetable and synthetic fluids are increasingly being used. High viscosity fluids, such as synthetic polybutenes and PAOs are also employed.

Thickeners: Many lubricant applications are enclosed in some sort of sump, therefore the lubricant is allowed to be either continuously splashed or sprayed onto moving parts. This is not true for most wire ropes. They are normally in the open exposed to wind, moisture, heat, and contamination. As already described a low viscosity fluid lubricant is effective at penetrating into the core of a wire rope, but it may not provide a long lasting coating. Any lubricant on exterior parts of the rope will just drip off. Thickeners are included to create a protective barrier between the external environment and the rope as well as to hold the lubricant in place. Common thickening additives can include waxes, resins, polymers, asphaltics, soaps, and solids. Waxes, resins, asphaltics, and polymers used are often solid to semi-solid materials that are dissolved in a solvent. Once applied the solvent evaporates a malleable coating is left behind. Typically, these end up providing better coating properties than lubricating properties. Soaps and solids described are similar to traditional grease thickener chemistry. The solids would include activated clays, carbon black, and fumed silica. Once again, environmental regulations may exclude the use of some of these materials, as most of them are not terribly biodegradable and many may not pass environmental toxicity testing.

Additives: Additives are included into wire rope lubricants to enhance desired performance properties. Common lubricant properties include friction modification (Antiwear and Extreme Pressure), corrosion prevention, oxidation resistance, and tackiness. It is normal that one might automatically expect a lubricant to provide wear reducing performance properties, but not all wire rope coatings are designed to be lubricants, so one must not assume a wire rope coating contains wear reducing

components. The wire rope coatings that are not designed to lubricate are usually designed as corrosion preventative products, especially rust, as many wire ropes are employed under wet and dirty environmental conditions. Often, if a wire rope coating product is designed to lubricate then it will also be designed to provide corrosion resistance properties as well. As the coatings are often exposed to the outdoors, they may also contain antioxidants to increase the longevity of the lubricant itself. As certain applications may require wire rope lubricant to be applied frequently, antioxidants may not always be necessary. Finally, it is important for a wire rope lubricant to adhere to the rods and strands of the rope. Therefore if the base fluids do not naturally possess these properties a tackifying additive may be included. As it has been noted that many wire rope applications are employed in environmentally sensitive areas, new regulatory requirements governing bioaccumulation and ecotoxicity properties may limit what additives can be used in a wire rope formulation.

Environmental Considerations

For years many have been marketing various lubricants, including wire rope lubricants, calling them environmentally friendly, environmentally acceptable, or environmentally considerate. Oftentimes, this claim was primarily based upon biodegradability performance only. Today, there are guidelines laid out by various organizations for marketing of products, such as the European Union's Ecolabel, Germany's Blue Angel, or the Nordic Swan ecolabel. For the first time, teeth have been given to environmental properties with the U. S. EPA Vessel General Permitting regulations. Whether a company wants to comply with regulations or just pursue the mentioned ecolabel approvals, it can have a dramatic affect on what ingredients can be used in a formulation. To better understand this, perhaps further details about the U.S. EPA VGP would be helpful. Vessel General Permit (VGP) Requirements: The United States Environmental Protection Agency regulates discharges of various effluents into the US waters by ships or vessels of certain size. The VGP in effect allows a vessel operator the AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM. It states "in compliance with the provisions of the Clean Water Act (CWA), as amended (33 USC 1251 et seq.), any owner or operator of a vessel being operated in a capacity as a means of transportation who is eligible for permit coverage; and if required submits a complete and accurate Notice of Intent (NOI) or completes a Permit Authorization and Record of Inspection (PARI) form, and retains it onboard the vessel is **authorized to discharge in accordance with the requirements of this permit.**"³

More specifically, the United States Environmental Protection Agency regulates discharges incidental to the normal operation of commercial vessels greater than 79 feet in length and operating as a means of transportation primarily through the Vessel General Permit (VGP). The first VGP was issued in 2008 and effective until December 19, 2013. On March 28, 2013, EPA re-issued the VGP for another five years. That reissued permit, the 2013 VGP, took effect December 19, 2013 and superseded the 2008 VGP at that time.

Effluents that include lubricants are those used on a ship in any of the following areas: Controllable Pitch Propeller and Thruster Hydraulic Fluid and other Oil Sea Interfaces including Lubrication Discharges from Paddle Wheel Propulsion, Stern Tubes, Thruster Bearings, Stabilizers, Rudder Bearings, Azimuth Thrusters, and Propulsion Pod Lubrication, and Wire Rope and Mechanical Equipment Subject to Immersion.

Example: Formulating Wire Rope Grease: VGP specifically targets wire ropes and equipment that are subject to immersion in water. As a result the vessel operators would need to either reduce or modify the use of lubricants that are considered bio-accumulative or resort to using biobased and no-bio accumulative lubricants. Both authors represent companies that manufacture and sell wire rope lubricants. While the use of wire rope lubricants extends beyond VGP to mining, forestry, construction and other applications, the focus of this article is the VGP use.

Wire rope lubricants, either in liquid or in grease form, can be applied in several ways including manually. But, there are many pumping systems that make the process more automated and effective. Figure 4 shows a schematic of a lubricator for applying oil to the rope.

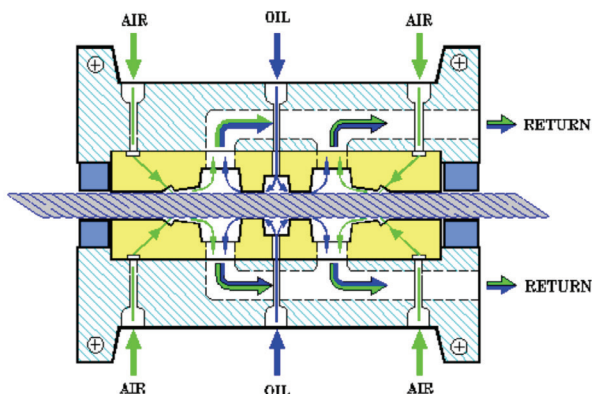
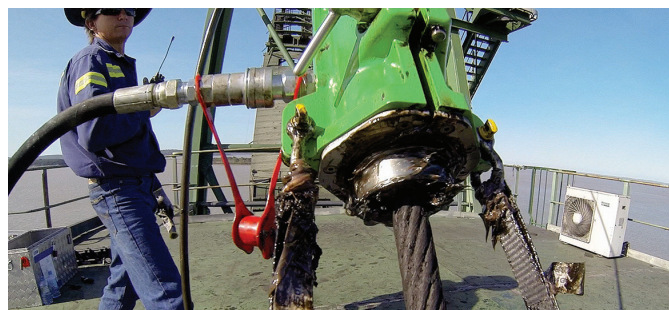


Figure 4. Schematic of a Lubricator Design (above) 4; and a Commercial Rope Lubricator (Courtesy Viper WRL Pty Ltd)

The grease or lubricant used near or around water would require specific properties particularly for protecting against rust and corrosion in salt water as well as resistance to water washout. Some of the properties correspond to those used in the food processing industry; where pressure washers are used to wash equipment thus exposing the grease to water washout conditions. As a result, food-grade type aluminum complex

greases are often used for wire rope grease applications although lithium and calcium versions as well as some non-soap organo-clay type greases are also found on the market. Since, the grease needs to be pumped on to the wire rope, some of the wire rope greases found on the market seems to range in consistency from NLGI Grade #00 to Grade #1. The Grade #1 greases being for use in hotter climates. The following tables show typical properties of a mineral oil based and a biobased wire rope grease.

NLGI GRADE		0	1
TYPICAL PROPERTIES	Colour	Brown	Brown
	Dropping Point (°C) ASTM D2265	--	273
	Penetration, 60 strokes ASTM D-217	355	280
	Four Ball Wear Scar (mm)	0.48	0.48
	Four Ball Weld Load (kg)	200	200
	Corrosion ASTM D-1743	Pass	Pass
	Base Oil Viscosity at 40 °C	129	129
	Base Oil Viscosity at 100 °C	20.4	20.4
	Base Oil Viscosity Index	182	182
	Base Oil Biodegradability OECD 201B	>60%	>60%
	Aquatic Toxicity OECD 202	Non-Toxic	Non-Toxic
	Bioaccumulation % OECD 305	0	0

Table 1. Typical properties of a biobased wire rope grease that meets VGP requirements

NLGI GRADE		000	
TYPICAL PROPERTIES	Appearance	Smooth	
	Dropping Point (°C) ASTM D2265	82	
	Unworked Penetration	460	
	Four Ball Wear Scar (mm)	0.5	
	Four Ball Weld Load (kg)	200	
	Corrosion ASTM D-1743	Pass	
	Base Oil Viscosity at 40 °C	144	
	Base Oil Viscosity at 100 °C	11.7	
	Base Oil Viscosity Index	55	

Table 2. Typical properties of a wire rope grease

Thanks to advances in the biobased lubricant technologies, today the cost of biobased greases are approaching parity with conventional type wire rope greases. This means that vessel operators now have options available to them to use non-bio-accumulative lubricants on the vessel wire ropes.

Conclusion

The Vessel General Permit requirements as required by the US Environmental Protection Agency, has created a new impetus for rethinking the use of conventional wire rope lubricants. Since, the ruling involves ships from all countries when navigating in US waters, the ramification of this requirement extends beyond the United States. There has been significant progress in developing products that are non-bioaccumulative and would meet the VGP requirements. More importantly, the VGP requirements could lead to development of other lubricant and grease products that would be environment friendly.

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